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BROMEGRASS

For

THE NORTHERN GREAT PLAINS

By

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INTRODUCTION

Bromegrass (Bromus inermis Leyss.), variously known as Hungarian brome, Austrian brome, Russian brome, smooth brome, and awnless brome, is an Eurasian grass which has long been in cultivation. It was first introduced into the United States about 1884, and soon became popular as a hay and pasture grass in the semi-arid farming regions. Until the merits of crested wheatgrass (Agropyron cristatum) became known, bromegrass probably was the most useful cultivated grass for the Northern Great Plains. At present, the opinion is generally held that crested wheatgrass surpasses brome in adaptability to this region. However, the present scarcity and high prices of the seed of crested wheatgrass will preclude its immediate extensive use, and bromegrass undoubtedly will find a place in any large-scale attempt to regrass abandoned farm lands.

HABITS OF GROWTH

Bromegrass is a sod-forming perennial, spreading aggressively underground by rootstocks or rhizomes. This feature is both a virtue and a fault. The formation of a dense, tough sod gives it excellent soil-binding qualities, and enables it to withstand heavy trampling by livestock. However, the sod usually becomes so dense in a few years that the productivity of the stand is markedly decreased. Though this "sod-bound" condition can be alleviated by shallow plowing, the practice is hardly feasible except in the case of small meadows. The grass normally grows 15 to 30 inches high. It tends to mat at the base, but the stems are generally quite leafy. Seed is produced abundantly in an open panicle.

Growth during the first year after seeding usually is slow, and no crop is produced except, perhaps, scant pasturage in the fall. Normally, good yields of forage are obtained the second year, and maximum yields the third year after sowing. Thereafter, yields tend to decline as the sod-bound condition becomes manifest. Although bromegrass does not start growth as early in the spring as crested wheatgrass, it starts about two weeks earlier than the native grasses, and usually remains green and growing somewhat later into the fall (2,30,38).* It excels the wheatgrasses in constancy of production throughout the season. "Of all our cultivated grasses, it comes the nearest to growing through our hot, dry trying summers" (35).

VARIETIES

Some work has been done in an attempt to select and propagate improved strains. The possibility of obtaining types superior to the common run of the species has been demonstrated, but there is little evidence of practical results. The listings in seed catalogs reflect no discrimination except reference in some cases to the region where the seed was produced.

* Numbers in parenthesis refer to "Literature Cited", p. 21

Strains can be selected which show marked variations in leafiness, height, vigor of tillering, yield, and chemical composition (15,46). Furthermore, according to Keyser (15) many of these isolations behave as pure lines and breed true to type. He suggests that strains showing high vigor in tillering and rhizome formation would be most desirable for pasture in that they would better withstand trampling. Strains showing low vigor in this respect would be most desirable for hay meadows, in that there would be less tendency to become sod-bound. There is little liklihood, however, of being able to obtain any specific type or strain of bromegrass on the market at the present time.

ADAPTATIONS

Climatic adaptations. Bromegrass is completely hardy to cold as experienced in the Northern Great Plains. It produces good crops of seed in the Dakotas and Western Canada (27). As late as 1924, brome was recommended by the experiment stations of North Dakota as the best permanent grass for use in the state (42). A plat of brome was maintained for 20 years at the Edgeley Substation in southeastern North Dakota (38). It has proven successful in Wyoming, particularly at the lower elevations in the northeastern part of the state (22,28). It is recommended for the dry lands of Colorado (8, 36). It is ranked with slender wheatgrass (Agropyron pauciflorum (Schwein).Hitchc., A. tenerum Vasey) and crested wheatgrass as among the most promising domestic species for dry-land pastures in Montana (18). Brome grass has given good results in Saskatchewan (39). It has shown promise in Alaska (5). It is one of the most successful of the cultivated species introduced into the mountain range lands of the west, making good growth from the foothills to above timber line (3). Brome is not well adapted to the warmer climates encountered in Kansas and southward (24,37). It was given a fairly thorough trial at Hays, Kansas, over a period of 22 years, and was concluded to be a failure from an economic standpoint. High temperatures were considered to be the critical factor (6). It has been tried in New Mexico, but offers promise only at higher elevations where cooler temperatures prevail (48).

Bromegrass ranks high in resistance to drought, in fact it seems to be better adapted to western regions of light rainfall than to the more humid East (27). Before the advent of crested wheatgrass in dry-land agriculture, brome was generally highly recommended for its drought enduring qualities (24,30,44). Practically all references to the species mention this feature. Writers now tend to reserve their superlatives for crested wheat, ranking brome or slender wheatgrass in second place among domestic grasses.

The drought endurance of bromegrass lies, in part at least, in its extensive root system. The roots of mature plants may reach depths of 7 or 8 feet, with a general working level as deep as 3.5 feet. In this respect it is almost as efficient as crested wheatgrass. The roots of the latter are described as being somewhat more profusely branched, thereby exposing a greater absorbing area. Seedlings of bromegrass excel crested wheatgrass in vigor of root development (19).

Soil adaptations. Bromegrass thrives best on deep, rich, fertile, silt or clay loams, well supplied with moisture, but compared with other grasses it does relatively well on lighter sandy soils (10,20,27,37). Its use as a soil binder on lands that are inclined to blow has been suggested (10,28). There are no data, however, to indicate that this species would be successful on areas of relatively sterile, loose sand. The fact that it tends to be a heavy user of nitrogen would indicate poor adaptability to such sites. On sandy soils of sufficient fertility to support bromegrass, it is preferable to most other species. Its dense sod is an effective soil binder and is highly resistant to the trampling of grazing animals.

Apparently, brome possesses some tolerance of soil alkali, but the degree of tolerance can not be definitely stated. Only two statements have been found regarding the question, and these are somewhat contradictory. Kirk (16) ranks brome below both slender and crested wheatgrasses in alkali tolerance, but does not give figures of the alkali content of the soils. Evidently, he made his rating on the basis of general comparative observations. Kearney (12), in a more careful study of alkali-tolerant plants, rated bromegrass ahead of slender wheat and next to western wheatgrass (Agropyron Smithii). He states that growth is unhindered where the alkali content of the soil is 0.5%, that plants make good growth and produce seed where the alkali content is 0.7%, and that seed production has been observed on areas where the alkali concentration was 1.5%. Although Kearney's rating would appear to be more reliable, it probably should not be accepted as more than a tentative guide. The tolerance of a species to alkali is subject to too many variables to warrant hard and fast statements. In the first place, the percentage of alkali in a soil, based on dry weight, may be misleading. The significant factor is the concentration of salts in the soil solution, and that will vary with the moisture content of the soil. A second variable is the stage of the plant's development in which it is subjected to the maximum concentration of alkali in the soil solution. Seedlings usually are more susceptible to injury than older plants. A third variable is the depth of the greatest concentration of alkali relative to the working depth of the root system. Deep-rooted plants may be absorbing below the level at which soil samples ordinarily are taken, in a soil solution far weaker than that in the surface layers. On the other hand, abundant moisture tends to carry the alkali down into the soil, and plants may do the bulk of their absorbing above the toxic level. The only conclusion that can safely be drawn in regard to bromegrass is that it is moderately tolerant of soil alkali, and may be planted with reasonable hope of success in areas where the salt content is below 0.7%. Failure to obtain a stand in any given season does not necessarily indicate that a stand may not be obtained by another trial under different seasonal conditions. A stand once established in such an area probably would maintain itself indefinitely.

CULTURE

Preparation of seed bed. A detailed discussion of this topic, with citations of specific sources of information, would seem to be unnecessary. Practically all of the experiment stations in the Great Plains and Northern Rocky Mountain area of the United States have included bromegrass in their pasture or crop rotation experiments. Their work demonstrates unquestionably that the chances of success in seeding brome or any other grass are in direct proportion to the amount of care with which the seed bed is prepared. The essential features are that it be fine, firm, mellow and moist. Preferably, grasses should follow inter-tilled crops, or be sown on fallowed land to minimize the growth of weeds. If plowing is done, it should precede the seeding date by several weeks or months, followed by surface cultivation to destroy weeds, conserve moisture, and promote conditions of good tilth. This allows the soil to settle, excessive aeration is inhibited, and capillary connections with the subsoil are restored.

Although less costly methods of preparation for seeding are highly desirable, their use undoubtedly will result in many failures, and their economic practicability will have to be established by field experience. Very little experimentation along this line has been done.

The cooperative experiments of the Northern Rocky Mountain Forest and Range Experiment Station in Montana are most pertinent in this connection. Various forage plants are being tried on abandoned cultivated dry land in an attempt to determine if reseeding methods consonant with the low value of the land can be developed. In most cases, drilling was done with no preparation of the soil except to burn the weeds where necessary. Preliminary results indicate success, according to range reseeding standards, on 35 or 40 per cent of the acreage sown. Some of this seeding was done in the fall of 1933 and the spring of 1934, thereby encountering one of the most severe droughts ever recorded in the state. Any success whatsoever is encouraging in the light of these conditions. Though crested wheatgrass is giving the best results in these trials, brome is listed among the more promising species for the region (11).

Some experiments in reseeding abandoned cultivated land without seed bed preparation are being carried on at the Dominion Range Experimental Station in Alberta, which is in the driest part of western Canada. Various grasses and legumes were sown by broadcasting, then disced once to cover the seed. The field was open to grazing. In this test, only crested wheatgrass became established; bromegrass was among the failures (16).

Brome and other grasses have been successfully seeded in the western mountain range lands with little or no soil preparation (3,29). However, climatic conditions are generally less rigorous in those areas than in the plains, and the methods employed can only be considered as suggestive of practices to be tried elsewhere.

Time of seeding. The most important factor affecting the choice of a seeding date is the amount of soil moisture. The effectiveness of the available moisture is inversely proportional, of course, to evaporation stress as manifested in the general atmospheric conditions. Hence, seeding should be done either in the fall or in early spring, when conditions favorable to the establishment of the seedlings are most likely to prevail. Early spring seeding is generally recommended, though fall seedings often have been successful. Seeding in April, early May, or in the fall is recommended for Montana (10). Hanson recommends sowing as early in the spring as possible in the eastern foothills of Colorado (8). At the Dakota experiment stations, spring sowing apparently is the usual procedure. In literature distributed by the Agricultural Adjustment Administration, early spring seeding of bromegrass in the Northern Great Plains is recommended (1).

In fall sowing, it is generally assumed that planting will be done sufficiently early to permit establishment of the seedlings and the formation of a good root system. Hence, seeding should be done as early as weather and soil conditions permit. At Lincoln, Nebraska, plants that had been sown August 19, went into the winter in a condition markedly superior to those sown September 15 and later. The seedlings resulting from late sowings are much more likely to winter-kill (20). It is possible, however, that some advantages might accrue from sowing in the fall at a date late enough to prevent germination, thereby giving the plants an earlier start in the spring than would be possible by spring sowing. This practice has been successful in the northwest Mountain range lands (3), but seems not to have been used on the plains. It should be given a trial.

Methods of seeding. The seed of bromegrass is light and chaffy, and will not feed satisfactorily through an ordinary drill. Various procedures have been used to make drill seeding possible. A shaker for use in an ordinary grain drill may be made as follows: "Nail together two narrow strips of inch board in the bottom of the seed box, splicing them in the center; drive two ten-penny nails through this board into each seed cup; attach to the middle of the board a handle which reaches to the top of the box. Put only a small amount of seed into the box at one time. With a boy working the handle to prevent the seed from clogging the drill, it is possible to do a fairly even job of seeding"(37). Mixing the seed with heavier inert material, such as lignite screenings (40), cracked wheat, or corn chop (36), will facilitate feeding thru the drill. If a nurse crop, such as wheat or barley is used, the grain seeds will serve in the same capacity. Frequent mixing is necessary to insure even sowing.

Some drills and seeders have attachments for handling light grass seed. These probably are most satisfactory when available.

Drilling generally is the preferable method of seeding when feasible. It insures a more thorough and even coverage than is otherwise possible. Hand seeders of various kinds may be used. On account of the mechanical difficulties incident to the chaffy character of the seed broadcasting is often recommended. Some treatment to cover the seed is essential with these methods. Harrowing is the usual procedure. Discing probably would be more effective on land that had undergone no preliminary

preparation. Various types of drags and brush harrows have been used. Though these may be practical in certain cases, they are relatively inefficient and generally not to be recommended.

Nurse crops generally are not recommended in the Great Plains (24, 37). Any beneficial effects of a nurse crop usually are more than counterbalanced by the resulting competition. Furthermore, a stand of grass may be ruined by the removal of the nurse crop in mid-summer. The sudden exposure of the tender plants to the wind and sun after growing under protection may be more than they can stand (37). However, a nurse crop may be beneficial in controlling weeds on badly infested land (24). If the soil is inclined to drift, wheat or some similar crop may be sown in rows 3 or 4 feet apart and across the sweep of the prevailing winds. This should be done several weeks in advance of the sowing to grass (17). If a nurse crop is deemed advisable, any of the cereal grains, or flax may be used. The latter is in some respects preferable, in that it sets up less vigorous competition. The nurse crop should be sown at about one-half the usual rate of seeding.

Depth of seeding. Like most other forage grasses, the seeds of bromegrass contain relatively little stored food, and therefore should be planted as shallowly as is consistent with the conditions of soil moisture. Though the seedling is reported to "make its way through two inches or even more of soil without much difficulty" (44), seeding to that depth probably would not generally give the maximum percentage of emergence. Depths of one-half to one inch are recommended (10,37).

Rate of seeding. Recommendations vary considerably with respect to rate of seeding. As much as 25 pounds per acre has been suggested, but 10 to 15 pounds is the usual rate. With seed of good quality, the percentage of germination is high, often running above 90 percent (44). Light seedings often may be practical, since brome spreads vigorously under ground, and soon thickens to a full cover. Seeding in rows has been practiced for hay production, in which case 3 or 4 pounds of seed per acre is sufficient. At the Dickinson Substation in North Dakota, brome seeded in rows 3.5 feet apart had thickened to almost a complete cover in three years (21).

Mixed seeding. Bromegrass suffers general condemnation because of its tendency to become sod-bound and unproductive after 3 to 5 years. Mixtures of grasses have not been tried extensively on dry lands, although widely used for pasture plantings under irrigation, and in regions less arid than the Great Plains. It would seem that brome sown in mixture with other dry-land forage plants might be worth further trial. The approach of the sod-bound condition might be delayed under these circumstances (24).

The final cost of obtaining a satisfactory plant cover may be appreciably lowered by mixed seedings. In an adverse climate, a mixture constitutes several chances of a "catch" in one operation, i.e., one species may germinate and survive in a particular situation when other species fail. The seeding of mixtures increases the chances of establishing the species best adapted to the site when the choice is uncertain. Furthermore, when the seed of a desirable species is costly, mixtures offer a means of obtaining a sparse stand of the plant without sacrificing completeness of ground cover. Under proper management, the best adapted species will tend to spread and take possession of the area.

Alfalfa and sweet clover have been used to some extent in mixture with bromegrass. Legumes are desirable components of the vegetation because of their soil enriching properties, as well as for forage. Though their use for grazing increases the dangers of livestock losses from bloat, the risk is much less when the legumes are grown in mixture with grasses than when grown alone. Also, the chances for loss from bloat on alfalfa can be materially reduced by such practices as delayed grazing until it is fairly mature, by providing an easily accessible supply of water at all times, and by never turning the animals on the pasture when they are empty. Indications are that the use of alfalfa in pasture mixtures will increase in the future as safe and practicable methods become better known.*

Sweet clover is valuable both for use in the mixture when seeded originally, and for later seeding into grass stands where legumes are needed. If not overpastured, it will maintain itself in many localities by reseeding. It also has the virtues of high productivity and tolerance to alkali. It is especially valuable in mixtures during the two years following seeding because it builds up the soil and gives a high yield during the second year. This gives the slow-growing grasses a better chance to become established.

Bromegrass-alfalfa mixtures have given some good results in North Dakota. At the Dickinson Substation, alfalfa is reported to maintain itself well and may even invade established bromegrass sod when allowed to seed (41). The mixture yielded more hay than bromegrass alone. At the Great Plains Field Station, brome-alfalfa, and brome-crested wheat-alfalfa mixtures were used. Contrary to the Dickinson reports, the bromegrass here tended to crowd out the alfalfa. The hay produced by these grass-alfalfa mixtures is excellent feed, but the yields are somewhat lower than for alfalfa alone (34).

Some experiments with pasture mixtures were conducted in eastern North Dakota on Fargo clay soils (43). According to this work "the introduction of bromegrass into the mixture tends to lower the total forage yields, while the introduction of sweet clover tends to raise them". However, the work was done in a more humid climate than that prevailing in the Great Plains, and alfalfa, red and white clovers, and timothy figured in the mixtures under investigation. The results are not strictly applicable farther west.

*This paragraph is based on interviews and correspondence with members of the Department of Agronomy, Nebraska Agricultural Experiment Station.

Wilson (49) records the experience of a rancher in Alberta, operating under conditions similar to those in north-central Montana. This grower has successfully seeded bromegrass both in the spring and in the fall, both with and without nurse crops, and both alone and in mixtures. He has used brome and slender wheatgrass at the rate of 7 pounds each per acre, and brome, slender wheat and sweet clover at the rate of 5 pounds each per acre. In the latter case, the slender wheatgrass and clover produce a crop the first year, and are subsequently crowded out by the brome. This is an isolated case, but the results are at least suggestive.

In connection with mixed seeding it may be noted that bromegrass seed sometimes comes on the market contaminated with quack-grass (Agropyron repens). Such seed is generally regarded as inferior and commands a lower price. Quack-grass, however, produces valuable forage. On areas where its presence would not constitute a menace to near-by farming land, the use of this cheaper seed would appear to be economically justified and perhaps desirable. Even if the quack-grass proved to be the better competitor, andassumed dominance, the value of the resulting cover would not be diminished. However, the possibilities of this result are rather remote, since quack-grass is not usually persistent under close grazing (26).

Care after seeding. One general principle can be enunciated with respect to all forage grasses: They should be protected from grazing during the first season after sowing, or at most, be grazed only lightly in the fall. If conditions are reasonably favorable, bromegrass will withstand regulated grazing thereafter.

When a nurse crop is used, it should be removed by midsummer. If many weeds are present, they should be clipped once or twice during the first season. High clipping is desirable, in order to minimize injury to the grass.

When the grass is drilled in rows for hay or seed production, some cultivation probably will be essential. When broadcast or close-drilled, no care after the first season should be necessary as long as the stand remains productive. The usual procedure in rejuvenating a meadow that has become sod-bound is to plow shallowly in early spring (May is recommended in the Northern Great Plains). A rigorous discing sometimes suffices, and is less costly. Such practices thin the plants somewhat, promote water absorption and aeration, all of which tend to accelerate nitrification processes. It has been shown that the sod-bound condition, with concommitant reduced yields, is to some extent a matter of plant nutrition. On heavy rich soils the grass remains productive for a longer period (24). Yields can be materially increased by manuring. "It is safe to conclude that the reduced yields of bromegrass after it has stood for a few years is as much due to the reduced fertility in the soil as to the density of the sod" (32).

The feasibility of applying any treatment to sod-bound stands of bromegrass, and the choice of treatment are matters to be determined by the prevailing local conditions. Attempts to maintain the grass permanently may not be economically justifiable in many places. The possibilities of eliminating brome in favor of some more desirable species, by either artificial or natural means, always should receive consideration.

GRAZING

Seasonal productivity. As noted in the remarks on habits of growth, brome starts early in the spring, grows late into the fall, and excels most species in the ability to continue growth during hot, dry weather in mid-summer. As a general statement applicable to the Northern Great Plains, it can be stated that brome starts 1 to 2 weeks earlier in the spring than the native range vegetation, and 1 to 2 weeks later than crested wheatgrass in the same locality. As a result of observations over a period of 10 years at Mandan, North Dakota, it is stated that bromegrass starts growth about April 1. The grasses are usually in condition for pasturing about three weeks after the growth starts (47).

Resistance to grazing and trampling. Bromegrass is generally regarded as tolerant of close grazing and highly resistant to trampling. No work has been found, however, which attempts definitely to rate the grazing tolerance of brome in comparison with other species. It proved to be less persistent than crested wheatgrass under grazing in Canada (17), but the tests were not well enough controlled to determine whether it was the grazing or other factors that were critical.

Because of the characteristic tough sod, brome forms an excellent soil binder and withstands excessive trampling. Its use is particularly recommended on sandy soils, or on areas that are inclined to wash or blow (24,28,47).

Carrying capacity and pasture values. It is commonly maintained that adapted cultivated grasses, including brome, are more productive than the native range vegetation. Such comparisons, however, are usually on the basis of hay produced, and are made during the earlier and most productive years in the life of the planted meadow. There are very few comparative studies of the carrying capacity of native and planted pastures. Some data on these points are summarized by Westover (47), and are quoted in some detail in the report on crested wheatgrass issued by this office. At Ardmore, South Dakota, an average monetary value was calculated over a period of 4 years for the pasturage yielded by crested wheat, brome, sweet clover, and native pasture. The average annual values per acre were respectively $7.70, $6.75, $6.63, and $4.43.

At Moccasin, Montana, the results of a 4-year experiment showed bromegrass pastures to have a slightly greater carrying capacity than crested wheat and sweet clover. The differences were scarcely significant. Four acres of bromegrass were required to carry a cow for six months.

At Dickinson, North Dakota, clipping experiments designed to simulate grazing showed crested wheatgrass to be most productive. Assigning crested wheatgrass a value of 100, the relative yields of brome, the native grasses, and slender wheat were 86, 77, and 62 respectively (on the basis of air-dry weights). The native prairie consisted of about 90 percent blue grama grass (Bouteloua gracilis), with 5 percent western wheatgrass, and 5 percent other grasses and weeds. The experiment ran from April 10 to August 10, 1928.

Stewart (referring to eastern Colorado) states that the tame grasses "do not seem to furnish any more pasture on a given rainfall than the native sod, and they will not survive as long a period of sustained drought" (36). He gives no experimental data to substantiate his statement. Oakley makes the following statement: "While it is impossible at the present time to secure definite data in regard to the carrying capacity of Bromus inermis pastures, it can be conservatively stated that both in favorable and unfavorable seasons they furnish more grazing in the western part of the Dakotas than the native grasses and more in the eastern part than Kentucky bluegrass" (24). A comparison of these quotations shows the difficulty of deriving any definite conclusion from the literature.

It should be pointed out that the native prairie, particularly when dominated by a sod-former such as western wheatgrass, becomes sod-bound as do stands of many of the cultivated grasses. The prairie responds to the same cultural treatments as do the cultivated grasses, i.e., cultivation or fertilization (23,45). Obviously a comparison of yields between a young, productive field of tame grass and the sod-bound prairie is fallacious. The most valid comparison, from a grazing standpoint, would be between the undisturbed prairie and a stand of cultivated grass at least ten years old. Apparently this has not often been done. It is probable that much of the apparent superiority of the tame grasses would fail to materialize under these circumstances, and that the contradictory opinions found in the literature often have resulted from a failure to consider fully the condition of the stands under comparison.

The available information would seem to warrant the tentative conclusion that crested wheat and bromegrass pastures will out-yield the native grasses of the plains during the height of their productive period. That they will continue to do so over long periods is very questionable.

Palatability and nutritive values. Bromegrass pasturage is ranked high in palatability to all classes of live stock. It is somewhat superior to the wheatgrasses for sheep. The palatability tables prepared by the Forest Service give both brome and the wheatgrasses a rating of 80 for cattle and horses. This represents the relative maximum of palatability. For sheep, the wheatgrasses are rated from 40 to 50, and brome is variously rated from 50 to 70 in different districts. This applies to summer grazing. Both brome and the wheatgrasses cure well on the ground on the western ranges, and furnish highly palatable winter forage.

Livestock are reported to choose bromegrass pasturage in preference to most other vegetation when given a choice. Shepperd (31) states that stock will pasture it in preference to timothy or the native grasses; Hansen (7) records a one-cow preference test in which brome and white clover were preferred to meadow fescue, orchard grass, tall fescue, and perennial rye grass; Kennedy (14) states that cows prefer brome to timothy or clover pasture and that horses prefer it to the native grasses in North Dakota.

Comparative chemical analyses of forage plants are available from several sources. The figures naturally show some disagreement, since chemical composition varies with the degree of maturity of the plants, vigor of growth, genetic strains, soils, and climatic conditions. There is general uniformity of opinion that bromegrass ranks high in nutritive values both as pasturage and as hay. Kennedy (14) wrote in 1899 that bromegrass produces "luxuriant pasture", and that it is "rich in flesh-forming ingredients". The essence of his statements has been repeated many times in later treatments of the species. Such differences in nutritive value as exist between brome and other tame dry-land grasses (crested wheatgrass possibly excepted) appear to be in favor of brome.

A series of comparative chemical analyses of brome, slender wheat, crested wheat, and the native grasses was made at Dickinson, North Dakota. Samples were taken twice monthly from April 10 to August 25. In average protein content, brome was lower than crested wheatgrass, but surpassed the other species. The percentage of crude fiber was slightly lower in brome than in any of the other grasses. A companion series of analyses was made on clippings taken twice monthly. Brome again ranked second to crested wheatgrass in protein content and showed the lowest content of crude fiber. The average percentages, as reported by Westover (47), are given in Table I.

TABLE I. Seasonal Averages of Analyses of Clipped and Unclipped Grasses at the Dickinson Substation, North Dakota, as Reported by Westover (47).

(Data calculated on the basis of hay containing 15 per cent moisture).

Grasses	Ash		Ether Extract		Crude Protein		Crude Fiber	
	Unclipped Plants	Clippings	Unclipped Plants	Clippings	Unclipped Plants	Clippings	Unclipped Plants	Clippings
Crested Wheatgrass	7.02	10.36	2.33	2.93	14.25	24.33	24.86	19.55
Slender Wheatgrass	8.00	10.09	2.27	3.09	11.67	21.35	27.48	20.86
Bromegrass	8.65	11.42	2.24	2.83	13.23	22.99	23.32	18.23
Native Grasses*	8.71		1.88		12.11		24.06	

* Samples taken monthly; other grasses taken twice monthly.

HAY

Bromegrass, if cut at the proper time, yields a good quality of hay. As a whole, however, it probably is better suited for grazing. When allowed to grow for hay, it tends to become sod-bound and unproductive sooner than when pastured. Furthermore, an area may be profitably pastured when production is too low to yield a satisfactory hay crop.

Yields. The yields of bromegrass hay vary not only in accordance with the soil and climatic factors, but also with the age of the stand. Reports of yields are likely to be misleading if it is not well understood that the figures given usually apply only to the relatively short productive period. Usually no hay crop is produced the first year after sowing; a fair crop is produced the second year, and the third year marks the height of production. Thereafter, yields decline, and after the fifth year are too light to be profitably harvested. On good, rich soils, or by fertilizing, profitable production may be maintained longer (24,32). As was indicated in a preceding section, the usual procedure, when a sod-bound meadow is to be retained in hay production, is rejuvenation by shallow plowing. This, however, is a relatively expensive treatment, and in addition, entails the loss of the crop for that year.

Kennedy (14) states that bromegrass will produce 1 to 4.5 tons of hay per acre. According to Oakley (24), yields as high as 3 or 4 tons per acre are not uncommon, and will usually average about 1.5 tons per acre for the 3 or 4 most productive years. These figures doubtless are too high for the Northern Great Plains, especially the poorer lands with which the present Federal Program is most concerned. Wilson (49) apparently considers yields of 0.5 to 1 ton per acre to be wholly satisfactory in Alberta and Northern Montana. Westover (47) has compiled comparative data on the yields of brome, slender wheatgrass and crested wheatgrass from the various field stations in the Northern Great Plains. In these tabulations, yields of bromegrass greater than 1.5 tons per acre are decidedly in the minority, and yields of less than 0.5 ton are not uncommon. The original paper should be consulted for further specific information.

In general, the yields of bromegrass hay average less than crested wheatgrass, and more than slender wheatgrass. At Moccasin, Montana, brome responded more markedly to increased rainfall, and outyielded crested wheat in the wetter years (47).

The experiment stations have frequently demonstrated that seeding grasses in rows on dry lands usually increases yields. Though this method might be practicable for small areas privately operated, it would appear to be unsuited to a large-scale program of land revegetation. Planting in rows necessitates cultivation; otherwise the interspaces will be occupied by weeds, or will be occupied in 2 or 3 years by the grass through vegetative extension (45). Furthermore, the hay is likely to be coarse and less palatable. Oakley and Westover (25) state that the row culture of grasses has not proved feasible.

Palatability and nutritive values. Bromegrass should be cut for hay at the height of the blooming period, or immediately thereafter when in the condition known as the "purple" (24,37). This interval during which the grass is in its prime is relatively short (13). However, due to the relatively large proportion of basal leafage, hay of fair quality can be cut even at the time of seed maturity (2,14). As a general rule, hay for cattle or sheep should be cut slightly earlier than when it is to be fed to horses. Properly cut and cured bromegrass hay is fairly palatable, but apparently is less relished by stock than are some other species. Crested wheatgrass is more acceptable to horses (47). Ratings for cured hay, comparable to the palatability tables prepared by the Forest Service for herbage on the ground, apparently are not available. Bromegrass hay is said to be equal to timothy in palatability and nutritive value (14,24,31,37). It usually does not equal timothy in commercial value (37) because the latter is better known, and typically has a better color. Oakley (24) and Garver (4) state that feeders generally agree that brome hay is slightly inferior to timothy. Brome is said to be more difficult to cure than some other grasses, and the color usually is inferior according to accepted standards.

Comparative chemical analyses (4-year averages) reported by Kirk (17) do not indicate striking differences between brome, slender wheat and crested wheatgrass hays. As is the case with the green foliage, bromegrass tends to run slightly higher in protein and slightly lower in fiber than the wheatgrasses. On the other hand, some analyses from North Dakota (42) show brome to be lower in protein and higher in fiber than slender and western wheatgrasses. Brome, however, contained about 40 per cent more protein than timothy. The tabulation is described as giving the "average composition of the grasses", but details as to number of samples and the time they were taken are not given. The literature contains many such analyses which, however, are almost useless for comparative purposes. As was noted in the discussion of grazing uses, chemical composition varies with environment, genetic strains, vigor of growth and degree of maturity. All of these factors must be considered, and equalized as nearly as possible, before any valid comparison of species can be made. A survey of the data indicates that all hay made from the commonly cultivated grasses, when cut at the right time and properly cured, is essentially similar in chemical composition. Other factors are of much greater significance in the selection of species for a planting program.

The variations in composition with stages of maturity are illustrated by data obtained at the Dickinson Substation, North Dakota, and reported by Westover (47). Some of these figures on the protein content of crested wheatgrass and brome are given in Table II. In this case, brome hay cut July 10 would have been significantly higher in protein than crested wheatgrass; cuttings made two weeks earlier or later would have shown smaller differences in favor of crested wheat.

TABLE II. Comparison of the protein content of crested wheatgrass and bromegrass at the Dickinson Substation, as reported by Westover (47).

	Crested Wheat	Brome
May 25 (both starting to head)-------	18.82%	19.93%
June 10----------	12.27%	14.57%
June 25 (both starting to bloom)-----	12.61%	11.94%
July 10----------	9.76%	11.68%
July 25 (crested wheat starting to mature)---	9.78%	9.20%

Hopper and Nesbitt (9) have prepared an excellent compilation of data on the chemical composition of forage grasses of the Great Plains. Both their own analyses and the analyses of others are included. All figures are reduced to a hay basis of 15 percent moisture, with notations as to the stage of maturity when the samples were taken. Some of their figures for the most important wild and cultivated grasses of the plains are given in Table III. For the most part, figures only for the flowering periods (when hay usually is cut) are reproduced here; those for bromegrass are given in greater detail. This tabulation illustrates, somewhat, the range of variation to be expected in hays of the same and of different species. The original paper should be consulted for further and more complete data in this connection.

The most significant feature of forage, its palatability, and digestibility and assimilation by the animal are rather too elusive to be evaluated by the chemist. No report of comparative digestion trials with bromegrass hay has been seen. However, it is a common observation that brome hay has a laxative effect on horses (4,24), and hence, is particularly unsuited for working animals.

TABLE III.- Chemical composition of important forage grasses, as reported by Hopper and Nesbitt (9).

(Data calculated on the basis of hay containing 15 per cent moisture)

Species	Notes as to Maturity, Samples, etc.	Ash	Crude Protein	Ether Extract	Crude Fiber	Nitrogen - Free Extract
Bromegrass	full bloom, July 10	8.18	7.79	1.36	34.76	32.91
"	before heading (average of 7)	9.38	15.14	1.62	23.56	35.30
"	blossom (average of 22)	8.16	8.30	1.93	29.96	36.15
"	seed maturing (average of 4)	9.83	8.97	1.93	25.50	38.77
"	average of 60 analyses by other investigators	7.43	10.52	3.21	25.74	38.10
Timothy	bloom (average of 3, 1919, 1920, and 1921	5.86	6.09	2.05	29.99	41.01
Crested wheatgrass	early full bloom, July 8	8.48	11.86	1.29	33.14	30.23
" "	bloom, July 17	5.71	6.33	1.38	31.88	39.70
" "	bloom, July 17	5.71	8.41	1.43	33.98	35.47
Slender wheatgrass	full bloom, July 10	6.43	5.75	1.22	36.40	35.20
" "	bloom	7.63	12.51	1.62	30.27	32.97
" "	bloom	7.15	11.05	2.88	30.25	33.67
Western wheatgrass	full bloom, July 9	6.65	10.79	1.48	31.01	35.07
" "	bloom	8.04	11.64	1.60	29.54	34.18
" "	bloom	8.53	8.98	2.22	29.24	36.23
Western Needlegrass	early bloom (full), June 30	8.96	9.72	3.11	26.37	36.84
" "	full bloom, July 8	5.18	5.74	1.16	35.54	37.38
" "	mature, August 20	5.56	4.04	2.13	33.37	39.85
Blue Gramagrass	early bloom, July 24	7.85	10.09	1.22	27.83	38.01
" "	past bloom, August 9	6.95	8.22	1.33	23.75	39.75
" "	past bloom, August 22	9.03	7.40	2.11	26.35	40.11
Buffalo grass	full bloom, July 28	8.87	9.99	2.01	22.86	41.27

SEED

Bromegrass produces seed in abundance and of high viability under favorable conditions. According to Piper (27), 250 to 600 pounds of seed are produced per acre. A bushel weighs from 10 to 20 pounds, (14 pounds is usually accepted as the standard weight) and contains about 137,000 seeds. The date of maturity in the Dakotas ranges from mid-July to August 10. Some maintain that brome seed shatters less after ripening than most other grasses (33); others warn against a tendency toward seed shattering, and state that losses are incurred if the crop is allowed to over-ripen even one day (2). These converse opinions probably have resulted from observations under different weather conditions.

Harvesting can be done with the ordinary binder or header. By running the harvester high enough to clear the basal leafage, a fairly good hay crop often can be obtained by subsequent mowing. Harvesting a mature seed crop may materially reduce the yield of hay or seed the following year (24).

Threshing is rather difficult on account of the light, chaffy character of the seed. Keim contends that heavier seed should be one of the objectives in any attempt to improve this species by breeding (13). Threshing can be done with the ordinary machine with special riddles and the wind shut off from the fan. A considerable amount of chaff and broken straw usually goes over with the seed, necessitating subsequent cleaning with a fanning mill (24).

Seed is grown commercially in the Dakotas, Manitoba, and Saskatchewan. It is listed by nearly all seed dealers, at prices of 30 to 35 cents per pound.

CONCLUSIONS AND RECOMMENDATIONS

Most of the material compiled in this report has been gleaned from the work of the experiment stations and the United States Department of Agriculture. The majority of such publications are, to some extent, recommendations of plants or practices, and as such, tend to emphasize desirable qualities and successes more than failures. It is of some significance, perhaps, that much of this material has been taken from the older literature, the authors of which lacked the benefit of the farming experience gained during the last two or three decades. Hence, they sometimes displayed a degree of enthusiasm which the more discriminating workers of recent years do not generally share. Furthermore, agriculture is not without its fads and fashions. A notable example is the manner in which crested wheatgrass has superseded bromegrass in experiment station literature as the grass *par excellence* for the Northern Great Plains.

However, it should be borne in mind that plant culture in this arid region always is a precarious undertaking, and failures must be taken as a matter of course. This report can furnish no more than general guidance. Success in the field will depend on the generous use of common sense plus a good deal of luck as expressed in the caprices of the weather. It is a matter of record that brome and other grasses have been successfully grown by many farmers in the arid northern plains. Those successes mostly have been on small tracts, carefully prepared by an operator with a direct personal interest. There is no assurance that large-scale and probably less intensive methods applied to the poorest lands under government management will result as well. In fact, there is an increasing amount of opinion and evidence indicating that on the poorer sites in the more arid sections, seeding forage plants will result in a preponderance of failures. Oakley and Westover reached the conclusion in 1924 that "little help may be expected from the cultivated perennial grasses in the drier parts of the region". They state that brome falls far short of making a profitable yield of hay, and is not markedly superior to the native vegetation for pasture (25).

In any program of revegetation, previous local experience should be investigated. The condition and types of soil should be known. Areas showing any tendency to revert to western wheatgrass probably had best be left alone. Within a given climatic region, the choice of species for planting should be governed by the character of the soil and availability of seed. On alkali lands in the northern plains, western wheatgrass probably is most promising, and brome would be a second choice. On average hard lands, crested wheatgrass probably is most promising, and brome would be second choice. On sandy areas, or areas where washing or trampling are likely to be severe, brome probably is best suited. With the present scarcity of seed of crested wheatgrass, and the lack of seed and experience in growing western wheatgrass, brome offers the most hope of immediate results over the northern plains as a whole.

The cultural methods should be the best that local conditions and available funds will permit. With inadequate seed bed preparation, success will depend, more than ever, on fortuitous rainfall and moderate temperatures.

SUMMARY

Bromegrass is a sod-forming perennial, which spreads aggressively underground by root stocks or rhizomes. Due to this habit, it becomes so dense in 3 or 4 years that the supply of moisture and available nutrients is somewhat depleted, the stand is said to be "sod-bound", and productivity declines. It starts growth early in the spring, continues late in the fall, and excels the wheatgrasses in constancy of production throughout the season. Normally, the plants produce a leafy basal mat, and about June 1, send up leafy flower stalks 15 to 30 inches tall.

Bromegrass is markedly resistant to cold and drought. It is climatically adapted to the Great Plains from the Canadian prairie provinces to northern Nebraska, and throughout the western mountain range lands from the foothils to timberline. It holds possibilities for seeding as far south as central Kansas, but being less well adapted to a warm climate, requires the most favorable sites. Its drought resistance is correlated with a vigorous and extensive root system.

It thrives best on deep, moist, and fertile silt or clay loams, but does relatively well on lighter sandy soils. It will tolerate soil alkali as high as 0.5 to 0.7 per cent.

The chances of success in seeding bromegrass are in direct proportion to the amount of care with which the seed bed is prepared. The essential features are that it be fine, firm, mellow, and moist. The economic practicability of seeding abandoned cultivated land without preparation remains to be determined. Some experiments along this line are being conducted, with promising preliminary results, at the Northern Rocky Mountain Forest and Range Experiment station in Montana.

Seeding may be done either in the spring or in the fall. Early spring usually is recommended in the Northern Great Plains. The conditions of soil moisture are most important in determining the choice of a seeding date. Fall sowing should either be done early (before mid-September) to allow time for good root development, or delayed late enough to prevent germination until spring.

Drilling is the best method of seeding, but is attended by difficulties due to the light, chaffy character of the seed. Either some sort of a shaker must be used in the drill box, or the seed must be mixed with some heavier material, such as lignite screenings or cracked grain. Because of these difficulties, the seed often is broadcast and harrowed or disced into the ground.

The seed should be covered one-half to one inch deep. A slightly greater depth might be wise if the top soil were dry.

Ten to fifteen pounds of seed per acre usually are sown.

Row culture has been recommended for hay production in arid regions. This requires three or four pounds of seed per acre.

Nurse crops generally are not recommended.

Mixed seedings have not been extensively used. Some trials with brome, slender wheatgrass and sweet clover have given favorable results.

Newly seeded areas should be protected from grazing during the first season, or at most, be grazed only lightly in the fall. Normally a stand will maintain itself under regulated grazing thereafter.

When seeded in rows, some cultivation probably will be essential the first season to control weeds. If the rows are to be maintained, cultivation will be necessary every year to control the vegetative extensions of the grass into the spaces between the rows.

When drilled or broadcasted, it probably will be beneficial to mow the weeds once or twice during the first season. The sickle bar should be raised in order to minimize injury to the grass. When stands have become sod-bound, rejuvenation can be effected by shallow plowing or rigorous discing. Fertilization, also, is distinctly beneficial in alleviating the sod-bound condition.

Bromegrass furnishes excellent grazing from early spring until late fall. It starts 1 to 2 weeks earlier than the native species, but not so early as crested wheatgrass. It makes more growth than most other grasses during the mid-summer period.

It is fairly persistent under close grazing. By reason of the characteristic tough sod, it withstands trampling very well, and is an excellent soil binder on lands inclined to wash or blow.

The carrying capacity of bromegrass pasture during its most productive years is somewhat higher than the native pastures. On an average, it probably is surpassed by crested wheatgrass in productivity.

Brome pasturage is given the maximum palatability rating (80) for horses and cattle, which rating is likewise given to the wheatgrasses. Brome surpasses the latter in palatability to sheep. The nutritive values of bromegrass are high. It usually shows a higher protein content than most other species.

Bromegrass yields palatable and nutritious hay when properly cut and cured. It should be cut just at the height of the blooming period or immediately thereafter. Early cutting is desirable for feeding to cattle and sheep; cutting at a slightly more mature stage makes better hay for horses. It is not desirable hay for work horses because of its laxative properties. Yields range from 0.5 to 2 tons per acre in the Northern Great Plains; under very favorable conditions, yields of 3 or 4 tons may be obtained.

The grass seeds abundantly, and viability usually is high, sometimes exceeding 90 percent. Yields range from 250 to 600 pounds of seed per acre. A bushel weighs from 10 to 20 pounds; 14 pounds usually is accepted as the standard weight.

Harvesting is done with an ordinary binder or header. Threshing is rather difficult because of the light, chaffy character of the seed. It can be done with the ordinary separator with special riddles and the wind shut off from the fan. Subsequent cleaning of the seed usually is necessary.

The seed are stocked by nearly all dealers. Present prices range from 30 to 35 cents per pound.

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